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Original article

Development and application of a scoring system to rate malnutrition screening tools used in older adults in community and healthcare settings – A MaNuEL study

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SUMMARY

Rationale: Many malnutrition screening tools are used to screen for risk of malnutrition in older adults. An aim of the Joint Programming Initiative (JPI) 'A Healthy Diet for a Healthy Life' (HDHL) MalNutrition in the ELderly Knowledge hub (MaNuEL) is to devise recommendations on the best tools to screen for risk of malnutrition in older adults in community and healthcare settings across Europe. The aim of this paper was to develop and apply a scoring system to rate malnutrition screening tools.
Methods: Using a targeted literature search strategy, 48 malnutrition screening tools used to screen for risk of malnutrition in older adults were identified across community, rehabilitation, residential care and hospital settings. Criteria to rate each tool were developed; these were based on published evidence and expert opinion. These criteria were translated into a scoring system.
Results: The scoring system had three equally weighted sections; validation, parameters and practicability, and was applied to all 48 tools. Overall, the highest scoring tools per setting for screening for risk of malnutrition in older adults were i) DETERMINE your health checklist for the community setting; ii) the Nutritional Form for the Elderly (NUFFE) for the rehabilitation setting; iii) the Short Nutritional Assessment Questionnaire-Residential Care (SNAQ^{RC}) for residential care and iv) both the Malnutrition Screening Tool (MST) and the Mini Nutritional Assessment Short Form Version 1 (MNA-SF-V1) for the hospital setting.
Conclusion: Setting-specific tools are more appropriate for use with older adults. These findings will inform recommendations for the optimal screening of geriatric malnutrition across Europe.

1. Introduction

Malnutrition screening, when conducted appropriately, can have many economic and healthcare benefits [1,2]. Current recommendations for malnutrition screening in community and healthcare settings tend to be generic with limited evidence for the efficacy of a malnutrition screening tool used in one setting

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successfully transferring to another. For example, the European Society for Clinical Nutrition and Metabolism (ESPEN) recommends the use of the Mini Nutritional Assessment Short Form (MNA-SF) for older adults; however, this recommendation is not setting-specific [3]. Risk factors for malnutrition differ between healthcare settings (e.g. duration of weight loss detects different types of malnutrition in the acute setting vs. the community setting) and recent evidence indicates that validation results vary when the same tool is used in different settings [4]. A tool deemed appropriate for one setting may not, therefore, be the correct choice for another.

Two systematic reviews have attempted to determine the most appropriate malnutrition screening tool for use with older adults in residential care and hospital settings [5,6]. These studies have focused on validation results alone (e.g. sensitivity and specificity) and have not considered other aspects of screening, such as the suitability of the parameters for older adults and whether or not the tool is practical for use in this population. Furthermore, an important issue with validation of malnutrition screening tools is the lack of a 'gold-standard' reference method against which the tool can be validated; therefore, validation studies are frequently inappropriately conducted. In the absence of a 'gold-standard', clinical assessment by a nutritionally trained healthcare professional, the Subjective Global Assessment (SGA) and the Mini Nutritional Assessment Full-Form (MNA-FF) are often considered acceptable reference standards, and are, therefore, considered as 'semi-gold standards' [7].

Many different parameters are used in malnutrition screening tools; these include anthropometric, biochemical, functional (physical, mental) and social measures. Some of these measures may be more suitable for use with older adults; for example, cognition, mobility, polypharmacy and living alone [8,9]. It is probable that the parameters used in some tools recommended for the general adult population may not be suitable for use with older adults. For example, substantial controversy surrounds the use of body mass index (BMI) below 18.5 kg/m^2 as a sole measure of malnutrition in older adults, with widespread agreement that a higher BMI cut-off should be considered and incorporated into malnutrition screening tools used with older adults [10]. Other parameters frequently used in malnutrition screening tools, such as biochemical measures, are acknowledged as unreliable and time-consuming measures of malnutrition or risk of malnutrition [11].

2. Materials and Methods

The Joint Programming Initiative (JPI) 'Healthy Diet for a Healthy Life' (HDHL) MalNutrition in the ELderly Knowledge Hub (MaNuEL) project is comprised of six work packages, with an overall aim of reviewing the existing evidence for the management of malnutrition in older adults. The aim of work package 2 was to review malnutrition screening tools currently used with older adults, and to derive recommendations on which tools are most appropriate to use in older adults in each community and healthcare setting [12]. This was to be achieved by; i) compiling a database of malnutrition screening tools used in older adults and writing a literature review [4], ii) developing criteria and a scoring system to rate tools and apply the system to tools currently used and iii) investigating the prevalence of risk of malnutrition across Europe using the tools which scored highest in part ii). This paper describes part ii), the creation of a scoring system to rate malnutrition screening tools used in older adults in community and healthcare settings and the application of this system to these tools to determine those that score highest.

2.1. Identification of malnutrition screening tools used in older adults

A thorough literature search was conducted by two qualified nutrition/dietetics researchers to identify malnutrition screening tools used in older populations (mean age $\geq$65) [4]. Inclusion criteria were:

- Studies reporting validity of a malnutrition screening tool in community, rehabilitation, residential care and hospital populations with a mean age of 65y or greater.
- Tools which report screening for risk of malnutrition, protein-energy malnutrition and/or undernutrition, regardless of the number of parameters.
- Tools which were developed in and/or validated in European and non-European populations, as many tools designed for non-European populations contain similar parameters to European tools. Furthermore, the diversity in ethnicity across Europe warrants the inclusion of these tools.

A database containing information on the tools identified was created; this was peer-reviewed by MaNuEL partners in Europe and New Zealand, and experts in Australia, Canada, the United Kingdom and the United States with expertise in geriatric malnutrition. Data recorded included type of validation, validation results, reference standard used, population size and setting. The database also contained information such as the parameters of the tool (i.e. what the tool asks/measures) and its practicability (e.g. time-taken, cost).

2.2. Development of criteria to rate malnutrition screening tools

Criteria to rate each tool were based on published evidence of malnutrition screening tools (these included evidence of appropriate screening, validation, suitability of parameters for use with older adults, qualitative research on barriers and facilitators to malnutrition screening), and expert consensus on the most important considerations for optimal malnutrition screening in older adults. Whether the tool was validated, the quality of the validation study, the practicability and evidence for inclusion of appropriate parameters for identification of risk of malnutrition in older adults were collated. The criteria were refined following extensive discussions with experts in the area of malnutrition screening in older adults (Tables 1 and 2; Fig. 1).

2.3. Development of a scoring system to rate tools

Once developed, the criteria were translated into a scoring system, which had three equally weighted domains; validation, parameters and practicability. Each domain contained a maximum of 15 points, with a total overall maximum score of 45 points. Within each domain, different weightings were agreed for each question, depending on the agreed significance of the criteria (Fig. 2).

2.4. Rating of malnutrition screening tools in different healthcare settings

The scoring system was applied twice by the same researcher to each of the 48 tools identified in our literature search [4]. If the tool was validated in multiple settings, the scoring was repeated for each setting. A scoring system database was created to input the scores for each of the three domains, which were compiled to give an overall score for the tool's performance in each setting. For tools which had multiple validation studies in the same setting, the

Table 1
Criteria to rate malnutrition screening tools in older adults.

Domain	Question No.	Question	Scoring		Justification
Validation	1	Has the tool been validated in an older population in the particular setting?	Yes - continue No - skip to question 9 and give score of 0 for validation domain		Only tools validated in a population with a mean age of ≥65 in the setting under investigation are to be considered for the validation domain.
Validation	2	Has the tool been validated in an older population in the particular setting and country/continent of interest?	No Yes	0 1	For the purpose of this study, as MaNuEL is an EU project, the tool should be rewarded if it has been validated in a European population. This can be changed if the scoring system is to be applied in alternative populations (e.g. the US or Australia).
Validation	3	Does the tool have evidence of construct, criterion and/or predictive validity in an older population in the particular setting?	No (apply score and skip to question 9) Construct only Criterion or predictive Criterion and predictive Construct, criterion and predictive	−1 0 1 2 2	It was decided that criterion validity was the most important type of validation for malnutrition screening tools, as it shows whether or not the tool accurately detects risk of malnutrition and/or malnutrition. However, if the tool also had predictive validity, it should be rewarded. If the tool has no evidence of validity, a score of −1 should be given for question 3 and the scorer should skip to question 9 (applying a score of zero for questions 4,5,6,7 and 8).
Validation	4	Rate the level of evidence (i.e. number of validation studies) of the tool in the particular setting.	1–2 studies − 3–4 studies − 5 + studies −	1 point 2 points 3 points	The number of validation studies for each tool per setting ranged from 1 to 8. These categories were formed accordingly.
Validation	5	For studies using the MNA-FF and/or SGA as the reference standard, rate the validation results. *Note: a tool validated against itself or a long version of itself will receive -1 from the points awarded*	Poor/none Fair/Good-Fair Good	0 1 3	The MNA-FF and SGA are considered equally acceptable reference methods, but less appropriate than clinical assessment by a nutritionally-trained professional. Rating of validation results are in accordance with Fig. 1.
Validation	6	For studies using clinical assessment by a nutritionally-trained professional as the reference standard, rate the validation results.	Poor/none Fair/Good-Fair Good	0 2 4	Clinical assessment by a nutritionally-trained professional is considered a superior reference method for validation studies. Therefore, this question is weighted higher than the previous question. Rating of validation results are in accordance with Fig. 1.
Validation	7	For studies using other reference methods, rate the validation results.	Poor/none Fair/Good-Fair Good	0 0 1	The tool will only be rewarded if it scores 'good' for validation results against a non-semi gold standard reference method. Rating of validation results are in accordance with Fig. 1.
Validation	8	For predictive validity studies, rate the validation results.	Poor/none Fair/Good-Fair Good	0 0 1	Predictive validity was considered inferior to criterion validity and is, therefore, weighted lower. Rating of validation results are in accordance with Fig. 1.
Parameters	9	Does the tool contain any of the following parameters?	*(Add 2 points for each − max score 8)* Recent weight loss; reduced intake/chewing or swallowing difficulties; reduced appetite; inability to self-feed		Our expert group agreed that these parameters should be scored highest for risk of malnutrition in older adults.

(*continued on next page*)

Table 1 (*continued*)

Domain	Question No.	Question	Scoring		Justification
Parameters	10	Does the tool contain any of the following parameters?	*(Add 1 point for each domain - max score 4)* Anthropometrics (BMI/MUAC/Calf-circumference), Health and Physical Function (Acute/chronic disease/recent surgery/GI dysfunction/mobility/polypharmacy/handgrip strength), Social (living or eating alone/financial issues/loneliness), Cognitive function (psychological/neuro-psychological issues)		Subjective parameters are important when screening for risk of malnutrition in older adults, as objective measurements may not be sufficient to use alone. Several subjective and objective parameters were categorised into 4 domains, with 1 point awarded for each domain the tool contains.
Parameters	11	Does the tool contain biochemical markers?	Yes No	−1 1	Biochemical markers have been found to be unreliable measures of risk of malnutrition in older adults.
Parameters	12	Valid adjustment for older adults	Not Applicable Yes No	2 2 0	A 'valid' adjustment includes: the tool was originally designed for use in older adults or a higher BMI cut-off for those ≥65y. An 'in-valid' adjustment includes tools in which an extra point is given for those ≥65 (not evidence-based). The option of 'not applicable' applies to tools which do not include age-specific parameters and, therefore, cannot be adjusted. A score of 2 is given to ensure these tools are not unnecessarily penalised.
Practicability	13 (i)	Number of parameters in the tool	8+ 5–8 1–4	0 3 5	The number of parameters in the identified tools ranged from 1 to 14. Therefore, categories of 1–4, 5–8 and 8 + were created.
Practicability	13 (ii)	Does the tool contain a 'high' time consuming parameter?	Yes No	−1 1	High time-consuming parameters are not advised for inclusion in malnutrition screening tools. Refer to Table 2.
Practicability	13 (iii)	Ratio of 'moderate' time-consuming parameters to 'low' time-consuming parameters	Higher ratio of 'moderate' 50:50 ratio Higher ratio of 'low'	1 2 3	If the tool contains more high-time consuming parameters than low time-consuming parameters, it is assumed that the tool takes longer to administer. Refer to Table 2.
Practicability	14	Does the tool require …	Laboratory use/DEXA/BIA Other measuring equipment (i.e. dynamometer) Weighing scales, tape or stadiometer Questionnaire only	1 0 1 3	The more complex the equipment needed to administer the tool, the less practical and more costly the tool will be to use. Weighing scales, tapes and/stadiometers are commonly found in the healthcare setting. DEXA, BIA and laboratory facilities are less common and more costly.
Practicability	15	Access to tool	Not downloadable Downloadable	0 1	The tool will score 1 point if it can be easily found and downloaded from the internet.
Practicability	16	Used by	Self-Administered only/Nutritionally trained professionals only/Unknown Multi-disciplinary staff e.g. nurses, physicians	0 1	If the tool can be used by multi-disciplinary staff, it will increase the ability to screen in the healthcare setting.
Practicability	17	Languages available	1 language used in the country/continent of interest Multiple languages in the country/continent of interest	0 1	As MaNuEL is an EU project, the availability of the tool in more than one EU language is considered more desirable. This can be changed for studies interested in alternative populations (e.g. the US or Australia).

BIA: Bioelectrical Impedance Analysis, BMI: Body Mass Index, DEXA: Dual Energy X-ray Absorptiometry, EU: European Union, GI: Gastro-Intestinal, MaNuEL: MalNutrition in the ELderly Knowledge Hub, MNA-FF: Mini Nutritional Assessment-Full Form, MUAC: Mid Upper Arm Circumference, SGA: Subjective Global Assessment.

Table 2.
High, medium and low time consuming parameters included in malnutrition screening tools used in older adults.

High				
Biochemical Markers	Body Composition (FM/FFM)			
Moderate				
Percentage Weight Loss	Ulna Length	Food Portions	Fluid Intake	Joint Issues
BMI	Demi-Span	Problems/Inability to Self-Feed	Avoidance of Certain Foods	Infection
Percentage Ideal Weight	Grip Strength	Psychological Issues	Supplements/Special Diets	Polypharmacy
Percentage Usual Weight	Oedema	Neuro-Psychological Issues	Enough Food at Home	Taste/Smell Difficulties
MUAC	Sores/Wounds	GI Dysfunction	Problems Food Shopping	No. Meals per Day
Calf Circumference	Fruit/Vegetable/Carbohydrate/Dairy Intake	Acute/Chronic Disease	Alcohol	Financial Issues
Low				
Age	Mobility	Public Transport	Help with Cooking	Recent Surgery
Smoking	Thin Appearance	Self-Perceived Health Status	Difficulty Cooking	
Reduced Food Intake	Exercise	Health Aid e.g. Walking Frame	Vision	
Reduced Appetite	Skipping Meals	Feeling Full Quickly	Traumatic Event (loss of family/friend)	
Self-perceived Weight	Who Prepares Meals	Feeling Weak/Sluggish	Living/Eating Alone	

BMI: Body Mass Index, FFM: Fat Free Mass, FM: Fat Mass, GI: Gastro-Intestinal, MUAC: Mid Upper-Arm Circumference.

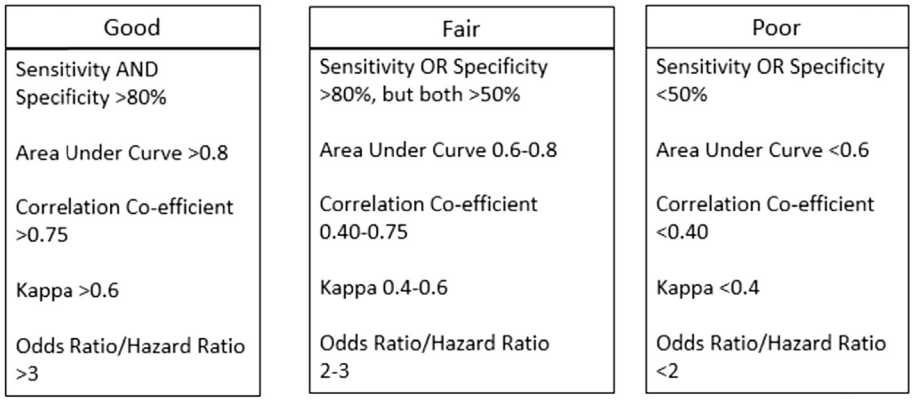

Fig. 1. Cut-offs for rating validation results (adapted from de van der Schueren et al., 2014). [5]

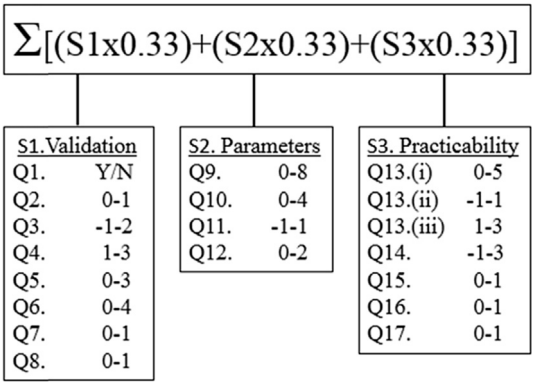

Fig. 2. Weightings of scoring system to rate malnutrition screening tools for older adults. S: Section, Q: Question.

median result for each measure was calculated. Median results (e.g. median sensitivity and specificity) were then used to score the tool's performance in the setting (i.e. applicable to questions five to eight in the scoring system).

3. Results

3.1. Overall results

The highest scoring malnutrition screening tools (combined score from three domains) were the DETERMINE your health checklist for the community setting, the Nutritional Form for the Elderly (NUFFE) for the rehabilitation setting, the Short Nutritional Assessment Questionnaire-Residential Care (SNAQ^{RC}) for residential care and both the Malnutrition Screening Tool (MST) and the Mini Nutritional Assessment Short Form Version 1 (MNA-SF-V1) for the hospital setting (Table 3). Total results for all 48 tools are presented in Table 4. Results per section (validation, parameters and practicability) can be found in Tables 5–7.

Table 3
Highest scoring malnutrition screening tools per healthcare setting.

Score		Community	Rehabilitation	Residential Care	Hospital
		DETERMINE	NUFFE	SNAQ^{RC}	MNA-SF Version 1/MST
Validation	(max 15)	7	6	7	8/8
Parameters	(max 15)	11	13	10	12/5
Practicability	(max 15)	8	7	11	6/13
Total	(max 45)	26	26	28	26/26

DETERMINE: Determine Your Health Checklist, MNA-FF: Mini Nutritional Assessment Short Form, MST: Malnutrition Screening Tool, NUFFE: Nutritional Form for the Elderly, SNAQ^{RC}: Short Nutritional Assessment Questionnaire Residential Care.

Table 4
Total scores for all malnutrition screening tools per healthcare setting.

	Validation				Parameters	Practicability	Total			
Tool	*Community*	*Rehabilitation*	*Residential Care*	*Hospital*			*Community*	*Rehabilitation*	*Residential Care*	*Hospital*
Australian NSI	2	0	0	0	9	5	16	14	14	14
African NST	5	0	5	0	9	4	18	13	18	13
Ayrshire NST	1	0	0	0	**13**	4	18	17	17	17
BAPEN NST	0	0	0	7	6	9	15	15	15	22
Chandra NST	0	0	0	2	9	6	15	15	15	17
CNAQ	0	3	1	2	9	9	18	21	19	20
CNS Chinese	0	0	5	4	12	5	17	17	22	21
Canadian NST	0	0	0	5	5	**13**	18	18	18	23
CONUT	0	0	0	9	-1	5	4	4	4	13
DETERMINE	**7**	0	2	0	11	8	**26**	19	21	19
ENS	0	0	0	0	7	8	15	15	15	15
EVS	0	0	0	3	10	5	15	15	15	18
GMS	0	0	0	4	11	8	19	19	19	23
GNRI	4	0	3	7	1	5	10	6	9	13
INA	0	0	0	3	-1	4	3	3	3	6
Icelandic NST	0	0	0	5	8	10	18	18	18	23
INSYST	0	0	0	0	8	7	15	15	15	15
Manchester NST	0	0	0	5	9	4	13	13	13	18
MEONF II	0	0	0	4	10	2	12	12	12	16
MI	2	0	0	1	-1	6	7	5	5	6
MNA-SF Self	3	0	0	0	10	6	19	16	16	16
MNA-SF V1	**7**	0	5	8	12	6	25	18	23	**26**
MNA-SF V2	6	3	6	5	12	6	24	21	24	23
MRST-C	2	0	0	0	11	6	19	17	17	17
MRST-H	4	0	0	2	9	7	20	16	16	18
MST	0	2	3	8	5	**13**	18	20	21	**26**
MUST	**7**	0	**7**	7	5	9	21	14	21	21
MUST Self	0	0	0	0	6	10	16	16	16	16
Nagel NST	0	0	0	0	6	-1	5	5	5	5
NNSA	0	0	0	2	**13**	4	17	17	17	19
NRAT	**7**	0	0	0	8	8	23	16	16	16
NRC	0	0	0	0	7	7	14	14	14	14
NRI	0	0	0	0	1	4	5	5	5	5
NRS	0	0	0	0	11	4	15	15	15	15
NRS-2002	0	0	0	**9**	7	8	15	15	15	24
NSA	0	0	0	0	6	2	8	8	8	8
NUFFE	3	**6**	0	4	**13**	7	23	**26**	20	24
NURAS	0	0	0	0	12	4	16	16	16	16
PEMU	0	0	0	0	6	7	13	13	13	13
RS	0	0	0	5	6	9	15	15	15	20
SCALES	0	0	0	0	6	3	9	9	9	9
SCREEN	2	0	0	0	10	5	17	15	15	15
SCREEN II	4	0	0	0	10	5	19	15	15	15
SNAQ-NL	4	0	0	0	5	**13**	22	18	18	18
SNAQ-NL +65	3	0	0	0	8	11	22	19	19	19
SNAQ-NL RC	0	0	**7**	0	10	11	21	21	**28**	21
SNAQ-US	0	2	0	3	3	**13**	16	18	16	19
SNST	0	0	0	3	6	11	17	17	17	20

*Bold: highest scores per domain. Abbreviations: BAPEN: British Association for Parenteral and Enteral Nutrition, CNAQ: Council on Nutrition Appetite Questionnaire, CNS: Chinese Nutritional Screen, CONUT: Controlling Nutritional Status, DETERMINE: Determine Your Health Checklist, ENS: Elderly Nutrition Screening, EVS: Eating Validation Scheme, GMS: Graz Malnutrition Screening, GNRI: Geriatric Nutritional Risk Index, INA: Instant Nutritional Assessment, INSYST: Imperial Nutritional Screening System, MEONF II: Minimal Eating Observation Form Version Two, MI: Maastricht Index, MNA-SF-V1: Mini Nutritional Assessment Short Form Version One, MNA-SF-V2: Mini Nutritional Assessment Short Form Version Two, MNA-Self: Mini Nutritional Assessment Self-Assessment, MRST-C: Malnutrition Risk Screening Tool - Community, MRST-H: Malnutrition Risk Screening Tool - Hospital, MST: Malnutrition Screening Tool, MUST: Malnutrition Universal Screening Tool, MUST Self: Malnutrition Universal Screening Tool – Self Screening, NNSA: Nursing Nutrition Screening Assessment, NRAT: Nutritional Risk Assessment Tool, NRC: Nutrition Risk Classification, NRI: Nutrition Risk Index, NRS-2002: Nutrition Risk Screening 2002, NSA: Nutrition Status Algorithm, NST: Nutritional Screening Tool, NUFFE: Nutritional Form for the Elderly, NURAS: Nutritional Risk Assessment Scale, PEMU: Pflegerische Erfassung von Mangelernährung und deren Ursachen in der stationären Langzeit-/Altenpflege, RS: Risk Screen, SCALES: Malnutrition Risk Scale, SCREEN: Seniors in the Community - Risk Evaluation for Eating and Nutrition Questionnaire, SCREEN II: Seniors in the Community - Risk Evaluation for Eating and Nutrition Questionnaire Version Two, SNAQ NL: Short Nutritional Assessment Questionnaire (the Netherlands Tool), SNAQRC: Short Nutritional Assessment Questionnaire - Residential Care, SNAQ-US: Simplified Nutritional Appetite Questionnaire (the United States Tool), SNST: Simple Nutritional Screening Tool.

Table 5
Validation results for malnutrition screening tools used in older adults in the community and rehabilitation setting.

	Section 1 - Validation (Community)										Section 1 – Validation (Rehabilitation)								
QUESTION NO.	Q. 1	Q. 2	Q. 3	Q. 4	Q. 5	Q. 6	Q. 7	Q. 8	Total		Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8	Total
WEIGHTING	Y/N	0-1	-1-2	1-3	0-3	0-4	0-1	0-1	-1-15		Y/N	0-1	-1-2	1-3	0-3	0-4	0-1	0-1	-1-15
SCREENING TOOL																			
Australian NST	Yes	0	1	1	0	0	0	0	2		No	0	0	0	0	0	0	0	0
African NST	Yes	0	1	1	3	0	0	0	5		No	0	0	0	0	0	0	0	0
Ayrshire NST	Yes	1	-1	1	0	0	0	0	1		No	0	0	0	0	0	0	0	0
BAPEN NST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
Chandra NST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
CNAQ	Yes	0	-1	1	0	0	0	0	0		Yes	0	1	1	1	0	0	0	3
Chinese CNS	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
Canadian NST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
CONUT	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
DETERMINE	Yes	1	2	2	0	2	0	0	7[a]		No	0	0	0	0	0	0	0	0
ENS	Yes	0	-1	1	0	0	0	0	0		No	0	0	0	0	0	0	0	0
EVS	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
GMS	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
GNRI	Yes	1	1	1	0	0	0	1	4		No	0	0	0	0	0	0	0	0
INA	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
Icelandic NST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
INSYST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
Manchester NST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
MEONF II	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
MI	Yes	1	0	1	0	0	0	0	2		No	0	0	0	0	0	0	0	0
MNA-SF Self	Yes	0	1	1	0	0	1	0	3		No	0	0	0	0	0	0	0	0
MNA-SF V1	Yes	1	1	3	2	0	0	0	7[a]		No	0	0	0	0	0	0	0	0
MNA-SF V2	Yes	1	1	2	2	0	0	0	6		Yes	1	1	1	0	0	0	0	3
MRST-C	Yes	0	1	1	0	0	0	0	2		No	0	0	0	0	0	0	0	0
MRST-H	Yes	0	1	1	0	2	0	0	4		No	0	0	0	0	0	0	0	0
MST	No	0	0	0	0	0	0	0	0		Yes	0	1	1	0	0	0	0	2
MUST	Yes	1	1	1	0	4	0	0	7[a]		No	0	0	0	0	0	0	0	0
MUST Self	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
Nagel NST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NNSA	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NRAT	Yes	1	1	1	0	4	0	0	7[a]		No	0	0	0	0	0	0	0	0
NRC	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NRI	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NRS	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NRS-2002	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NSA	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NUFFE	Yes	1	1	1	0	0	0	0	3		Yes	1	2	1	0	2	0	0	6[a]
NURAS	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
PEMU	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
RS	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
SCALES	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
SCREEN	Yes	0	1	1	0	0	0	0	2		No	0	0	0	0	0	0	0	0
SCREEN II	Yes	0	1	1	0	2	0	0	4		No	0	0	0	0	0	0	0	0
SNAQ-NL	Yes	1	1	1	0	0	1	0	4		No	0	0	0	0	0	0	0	0
SNAQ-NL +65	Yes	1	1	1	0	0	0	0	3		No	0	0	0	0	0	0	0	0
SNAQ-NL RC	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
SNAQ-US	No	0	0	0	0	0	0	0	0		Yes	0	1	1	0	0	0	0	2
SNST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0

BAPEN: British Association for Parenteral and Enteral Nutrition, CNAQ: Council on Nutrition Appetite Questionnaire, CNS: Chinese Nutritional Screen, CONUT: Controlling Nutritional Status, DETERMINE: Determine Your Health Checklist, ENS: Elderly Nutrition Screening, EVS: Eating Validation Scheme, GMS: Graz Malnutrition Screening, GNRI: Geriatric Nutritional Risk Index, INA: Instant Nutritional Assessment, INSYST: Imperial Nutritional Screening System, MEONF II: Minimal Eating Observation Form Version Two, MI: Maastricht Index, MNA-SF-V1: Mini Nutritional Assessment Short Form Version One, MNA-SF-V2: Mini Nutritional Assessment Short Form Version Two, MNA-Self: Mini Nutritional Assessment Self-Assessment, MRST-C: Malnutrition Risk Screening Tool - Community, MRST-H: Malnutrition Risk Screening Tool - Hospital, MST: Malnutrition Screening Tool, MUST: Malnutrition Universal Screening Tool, MUST Self: Malnutrition Universal Screening Tool – Self Screening, NNSA: Nursing Nutrition Screening Assessment, NRAT: Nutritional Risk Assessment Tool, NRC: Nutrition Risk Classification, NRI: Nutrition Risk Index, NRS-2002: Nutrition Risk Screening 2002, NSA: Nutrition Status Algorithm, NST: Nutritional Screening Tool, NUFFE: Nutritional Form for the Elderly, NURAS: Nutritional Risk Assessment Scale, PEMU: Pflegerische Erfassung von Mangelernährung und deren Ursachen in der stationären Langzeit-/Altenpflege, RS: Risk Screen, SCALES: Malnutrition Risk Scale, SCREEN: Seniors in the Community - Risk Evaluation for Eating and Nutrition Questionnaire, SCREEN II: Seniors in the Community - Risk Evaluation for Eating and Nutrition Questionnaire Version Two, SNAQ NL: Short Nutritional Assessment Questionnaire (the Netherlands Tool), SNAQRC: Short Nutritional Assessment Questionnaire - Residential Care, SNAQ-US: Simplified Nutritional Appetite Questionnaire (the United States Tool), SNST: Simple Nutritional Screening Tool.
[a] Highest Score.

Table 6
Validation results for malnutrition screening tools used in older adults in residential care and hospital setting.

	Section 1 - Validation (Residential Care)										Section 1 – Validation (Hospital)								
QUESTION NO.	Q. 1	Q. 2	Q. 3	Q. 4	Q. 5	Q. 6	Q. 7	Q. 8	Total		Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8	Total
WEIGHTING	Y/N	0-1	-1-2	1-3	0-3	0-4	0-1	0-1	-1-15		Y/N	0-1	-1-2	1-3	0-3	0-4	0-1	0-1	-1-15
SCREENING TOOL																			
Australian NST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
African NST	Yes	0	1	1	3	0	0	0	5		No	0	0	0	0	0	0	0	0
Ayrshire NST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
BAPEN NST	No	0	0	0	0	0	0	0	0		Yes	1	1	1	0	4	0	0	7
Chandra NST	No	0	0	0	0	0	0	0	0		Yes	0	1	1	0	0	0	0	2
CNAQ	Yes	0	0	1	0	0	0	0	1		Yes	0	1	1	0	0	0	0	2
Chinese CNS	Yes	0	1	1	1	2	0	0	5		Yes	0	1	1	0	2	0	0	4
Canadian NST	No	0	0	0	0	0	0	0	0		Yes	0	2	1	1	0	0	1	5
CONUT	No	0	0	0	0	0	0	0	0		Yes	1	1	2	1	4	0	0	9[a]
DETERMINE	Yes	0	1	1	0	0	0	0	2		No	0	0	0	0	0	0	0	0
ENS	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
EVS	No	0	0	0	0	0	0	0	0		Yes	1	1	1	0	0	0	0	3
GMS	No	0	0	0	0	0	0	0	0		Yes	1	1	1	0	0	1	0	4
GNRI	Yes	1	1	1	0	0	0	0	3		Yes	1	2	3	0	0	0	1	7
INA	No	0	0	0	0	0	0	0	0		Yes	0	1	1	0	0	0	1	3
Icelandic NST	No	0	0	0	0	0	0	0	0		Yes	1	1	1	0	2	0	0	5
INSYST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
Manchester NST	No	0	0	0	0	0	0	0	0		Yes	1	1	1	0	2	0	0	5
MEONF II	No	0	0	0	0	0	0	0	0		Yes	1	1	1	1	0	0	0	4
MI	No	0	0	0	0	0	0	0	0		Yes	1	0	0	0	0	0	0	1
MNA-SF Self	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
MNA-SF V1	Yes	0	1	1	3	0	0	0	5		Yes	1	2	3	1	0	0	1	8
MNA-SF V2	Yes	1	1	2	2	0	0	0	6		Yes	1	1	1	2	0	0	0	5
MRST-C	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
MRST-H	No	0	0	0	0	0	0	0	0		Yes	0	1	1	0	0	0	0	2
MST	Yes	0	1	1	1	0	0	0	3		Yes	1	1	3	3	0	0	0	8
MUST	Yes	1	2	2	1	0	0	1	7[a]		Yes	1	2	3	1	0	0	0	7
MUST Self	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
Nagel NST	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NNSA	No	0	0	0	0	0	0	0	0		Yes	1	0	1	0	0	0	0	2
NRAT	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NRC	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NRI	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NRS	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NRS-2002	No	0	0	0	0	0	0	0	0		Yes	1	2	3	3	0	0	0	9[a]
NSA	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
NUFFE	No	0	0	0	0	0	0	0	0		Yes	1	1	1	1	0	0	0	4
NURAS	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
PEMU	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
RS	No	0	0	0	0	0	0	0	0		Yes	0	2	1	0	2	0	0	5
SCALES	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
SCREEN	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
SCREEN II	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
SNAQ-NL	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
SNAQ-NL +65	No	0	0	0	0	0	0	0	0		No	0	0	0	0	0	0	0	0
SNAQ-NL RC	Yes	1	1	1	0	4	0	0	7[a]		No	0	0	0	0	0	0	0	0
SNAQ-US	No	0	0	0	0	0	0	0	0		Yes	0	1	1	1	0	0	0	3
SNST	No	0	0	0	0	0	0	0	0		Yes	0	1	1	1	0	0	0	3

BAPEN: British Association for Parenteral and Enteral Nutrition, CNAQ: Council on Nutrition Appetite Questionnaire, CNS: Chinese Nutritional Screen, CONUT: Controlling Nutritional Status, DETERMINE: Determine Your Health Checklist, ENS: Elderly Nutrition Screening, EVS: Eating Validation Scheme, GMS: Graz Malnutrition Screening, GNRI: Geriatric Nutritional Risk Index, INA: Instant Nutritional Assessment, INSYST: Imperial Nutritional Screening System, MEONF II: Minimal Eating Observation Form Version Two, MI: Maastricht Index, MNA-SF-V1: Mini Nutritional Assessment Short Form Version One, MNA-SF-V2: Mini Nutritional Assessment Short Form Version Two, MNA-Self: Mini Nutritional Assessment Self-Assessment, MRST-C: Malnutrition Risk Screening Tool - Community, MRST-H: Malnutrition Risk Screening Tool - Hospital, MST: Malnutrition Screening Tool, MUST: Malnutrition Universal Screening Tool, MUST Self: Malnutrition Universal Screening Tool – Self Screening, NNSA: Nursing Nutrition Screening Assessment, NRAT: Nutritional Risk Assessment Tool, NRC: Nutrition Risk Classification, NRI: Nutrition Risk Index, NRS-2002: Nutrition Risk Screening 2002, NSA: Nutrition Status Algorithm, NST: Nutritional Screening Tool, NUFFE: Nutritional Form for the Elderly, NURAS: Nutritional Risk Assessment Scale, PEMU: Pflegerische Erfassung von Mangelernährung und deren Ursachen in der stationären Langzeit-/Altenpflege, RS: Risk Screen, SCALES: Malnutrition Risk Scale, SCREEN: Seniors in the Community - Risk Evaluation for Eating and Nutrition Questionnaire, SCREEN II: Seniors in the Community - Risk Evaluation for Eating and Nutrition Questionnaire Version Two, SNAQ NL: Short Nutritional Assessment Questionnaire (the Netherlands Tool), SNAQRC: Short Nutritional Assessment Questionnaire - Residential Care, SNAQ-US: Simplified Nutritional Appetite Questionnaire (the United States Tool), SNST: Simple Nutritional Screening Tool.
[a] Highest Score.

Table 7
Parameters and practicability results for malnutrition screening tools used in older adults from the scoring system.

Section 2 - Parameters							Section 3 - Practicability							
QUESTION NO.	Q.9	Q. 10	Q. 11	Q.12	Total		Q. 13(i)	Q. 2(ii)	Q. 3(iii)	Q. 14	Q. 15	Q. 16	Q. 17	Total
WEIGHTING	0-8	0-4	-1-1	0-2	-1-15		0-5	-1-1	1-3	-1-3	0-1	0-1	0-1	-2-15
SCREENING TOOL														
Australian NST	6	2	1	0	9		0	1	1	3	0	0	0	5
African NST	2	4	1	2	9		0	1	1	1	0	1	0	4
Ayrshire NST	8	2	1	2	13[a]		0	1	1	1	0	1	0	4
BAPEN NST	4	1	1	0	6		5	1	1	1	0	1	0	9
Chandra NST	4	2	1	2	9		0	1	1	3	0	1	0	6
CNAQ	4	2	1	2	9		3	1	1	3	1	0	0	9
Chinese CNS	6	3	1	2	12		0	1	1	3	0	0	0	5
Canadian NST	4	0	1	0	5		5	1	2	3	1	1	0	13[a]
CONUT	0	0	-1	0	-1		5	-1	0	-1	0	1	1	5
DETERMINE	6	2	1	2	11		0	1	1	3	1	1	1	8
ENS	4	0	1	2	7		0	1	2	3	0	1	1	8
EVS	6	1	1	2	10		0	1	1	1	0	1	1	5
GMS	6	2	1	2	11		3	1	1	1	0	1	1	8
GNRI	0	0	-1	2	1		5	-1	1	-1	0	0	1	5
INA	0	0	-1	0	-1		5	-1	0	-1	0	1	0	4
Icelandic NST	4	1	1	2	8		5	1	1	1	0	1	1	10
INSYST	6	1	1	0	8		3	1	1	1	0	1	0	7
Manchester NST	6	2	1	0	9		0	1	1	1	0	1	0	4
MEONF II	8	1	-1	2	10		0	-1	1	-1	1	1	1	2
MI	0	0	-1	0	-1		5	-1	1	-1	0	1	1	6
MNA-SF Self	4	3	1	2	10		0	1	1	1	1	1	1	6
MNA-SF V1	6	3	1	2	12		0	1	1	1	1	1	1	6
MNA-SF V2	6	3	1	2	12		0	1	1	1	1	1	1	6
MRST-C	6	2	1	2	11		0	1	1	3	0	1	0	6
MRST-H	4	2	1	2	9		3	1	1	1	0	1	0	7
MST	4	0	1	0	5		5	1	2	3	1	1	0	13[a]
MUST	2	2	1	0	5		3	1	1	1	1	1	1	9
MUST Self	4	1	1	0	6		5	1	1	1	1	1	0	10
Nagel NST	6	1	-1	0	6		0	-1	1	-1	0	0	0	-1
NNSA	8	2	1	2	13[a]		0	1	1	1	0	1	0	4
NRAT	6	1	1	0	8		0	1	3	3	0	1	0	8
NRC	4	2	1	0	7		3	1	1	1	0	1	0	7
NRI	2	0	-1	0	1		5	-1	1	-1	0	0	0	4
NRS	8	2	1	0	11		0	1	1	1	0	1	0	4
NRS-2002	4	2	1	0	7		3	1	1	1	1	1	0	8
NSA	6	1	-1	0	6		3	-1	1	-1	0	0	0	2
NUFFE	8	2	1	2	13[a]		0	1	1	3	0	1	1	7
NURAS	6	3	1	2	12		0	1	1	1	0	1	0	4
PEMU	4	1	1	0	6		3	1	1	1	1	0	0	7
RS	2	1	1	2	6		5	1	1	1	0	1	0	9
SCALES	6	1	-1	0	6		3	-1	1	-1	0	1	0	3
SCREEN	6	1	1	2	10		0	1	1	1	0	1	1	5
SCREEN II	6	1	1	2	10		0	1	1	1	0	1	1	5
SNAQ-NL	4	0	1	0	5		5	1	1	3	1	1	1	13[a]
SNAQ-NL +65	4	1	1	2	8		5	1	1	1	1	1	1	11
SNAQ-NL RC	6	1	1	2	10		5	1	1	1	1	1	1	11
SNAQ-US	2	0	1	0	3		5	1	2	3	0	1	1	13[a]
SNST	4	1	1	0	6		5	1	2	3	0	0	0	11

CNAQ: Council on Nutrition Appetite Questionnaire, CNS: Chinese Nutritional Screen, CONUT: Controlling Nutritional Status, DETERMINE: Determine Your Health Checklist, ENS: Elderly Nutrition Screening, EVS: Eating Validation Scheme, GMS: Graz Malnutrition Screening, GNRI: Geriatric Nutritional Risk Index, INA: Instant Nutritional Assessment, INSYST: Imperial Nutritional Screening System, MEONF II: Minimal Eating Observation Form Version Two, MI: Maastricht Index, MNA-SF-V1: Mini Nutritional Assessment Short Form Version One, MNA-SF-V2: Mini Nutritional Assessment Short Form Version Two, MNA-Self: Mini Nutritional Assessment Self-Assessment, MRST-C: Malnutrition Risk Screening Tool - Community, MRST-H: Malnutrition Risk Screening Tool - Hospital, MST: Malnutrition Screening Tool, MUST: Malnutrition Universal Screening Tool, MUST Self: Malnutrition Universal Screening Tool – Self Screening, NNSA: Nursing Nutrition Screening Assessment, NRAT: Nutritional Risk Assessment Tool, NRC: Nutrition Risk Classification, NRI: Nutrition Risk Index, NRS-2002: Nutrition Risk Screening 2002, NSA: Nutrition Status Algorithm, NST: Nutritional Screening Tool, NUFFE: Nutritional Form for the Elderly, NURAS: Nutritional Risk Assessment Scale, PEMU: Pflegerische Erfassung von Mangelernährung und deren Ursachen in der stationären Langzeit-/Altenpflege, RS: Risk Screen, SCALES: Malnutrition Risk Scale, SCREEN: Seniors in the Community - Risk Evaluation for Eating and Nutrition Questionnaire, SCREEN II: Seniors in the Community - Risk Evaluation for Eating and Nutrition Questionnaire Version Two, SNAQ NL: Short Nutritional Assessment Questionnaire (the Netherlands Tool), SNAQRC: Short Nutritional Assessment Questionnaire - Residential Care, SNAQ-US: Simplified Nutritional Appetite Questionnaire (the United States Tool), SNST: Simple Nutritional Screening Tool.

[a] Highest Score.

3.2. Validation

Forty-eight malnutrition screening tools were identified as being used in older adults, of which 34 had been validated in this population. Tools generally scored poorly with regard to validation across all settings. Results in the community ranged from 4 to 7 out of a maximum 15 points, 2–6 out of 15 in rehabilitation, 1–7 out of 15 in residential care and 5–9 out of 15 in hospitals. The highest scoring tools for their validation studies were DETERMINE, MNA-SF-V1, the Malnutrition Universal Screening Tool (MUST) and the Nutritional Risk Assessment Tool (NRAT) in the community (7/15), NUFFE in rehabilitation (6/15), MUST and SNAQ^{RC} in residential care (7/15) and Controlling Nutritional Status (CONUT) and the Nutrition Risk Screening (NRS-2002) in the hospital setting (9/15). The strongest validation (highest result) was found in the hospital setting, with the weakest (lowest result) found in rehabilitation.

3.2.1. Validation in the community

Twenty malnutrition screening tools were validated in older adults in the community setting, of which 11 were validated in a European population. Sixteen tools had evidence of criterion and/or predictive validity in this setting. The MNA-SF-V1 had the highest level of evidence in the community; all of these validation studies used the MNA-FF as the validation reference method. In terms of validation results (i.e. sensitivity and specificity), the South African Nutrition Screening Tool (African NST), a tool very similar to many European tools, scored highest in studies against the MNA-FF and/or SGA. MUST and NRAT scored highest for validation results against clinical assessment by a nutritionally trained professional. The Geriatric Nutritional Risk Index (GNRI) scored highest for predictive validity. Validation results in the community setting can be found in Table 5.

3.2.2. Validation in rehabilitation

Five malnutrition screening tools were validated in older adults in the rehabilitation setting, of which two were validated in a European population. All five tools had evidence of criterion and/or predictive validity; however, all scored low for level of evidence (all scored 1 point). No tool scored highly against the MNA-FF and/or SGA or clinical assessment by a nutritionally-trained professional, with the best results scoring fair/good-fair for the Council on Nutrition Appetite Questionnaire (CNAQ) against the MNA-FF and the NUFFE against clinical assessment by a nutritionally-trained professional. No predictive validity was reported in this setting. Validation results for the rehabilitation setting can be found in Table 5.

3.2.3. Validation in residential care

Ten malnutrition screening tools had evidence of validation in older adults in the residential care setting, with four validated in a European population. Nine tools had evidence of criterion and/or predictive validity. MUST and the MNA-SF-V2 (Mini Nutritional Assessment Short Form Version 2) had the highest level of evidence in this setting. The South African NST and MNA-SF-V1 scored highest for validation results against the MNA-FF and/or SGA, while SNAQ-RC scored highest against clinical assessment by a nutritionally-trained professional. MUST scored highest for predictive validity. Validation results for the residential care setting can be found in Table 6.

3.2.4. Validation in the hospital setting

Twenty-five malnutrition screening tools had evidence of validation in older adults in the hospital setting, of which 16 were validated in a European population. Twenty-three tools demonstrated criterion and/or predictive validity in this setting. The GNRI, MNA-SF-V1, MST, MUST and NRS-2002 scored highest for level of evidence. The MST and the NRS-2002 scored highest for validation results against the MNA-FF and/or SGA. The British Association for Parenteral and Enteral Nutrition based tool (BAPEN NST) and CONUT scored highest for validation results against clinical assessment by a nutritionally-trained professional. The Canadian Nutritional Screening Tool (Canadian NST), GNRI, the Instant Nutritional Assessment (INA) and MNA-SF-V1 scored highest for predictive validity results. Validation results for the hospital setting can be found in Table 6.

3.3. Parameters

Scores for parameters contained within each malnutrition screening tool ranged from −1 to 13 out of 15 points, with the Ayrshyre Screening Tool (Ayrshyre NST), the Nursing Nutrition Screening Assessment (NNSA) and NUFFE scoring highest (13/15) and the INA scoring poorest (−1/15). Nine tools contained a biochemical marker and were, therefore, assigned a negative mark (−1 point). Twenty-five tools had a valid adjustment for older adults. Five tools contained all four of the parameters which were given the highest score (2 points for each parameter) – Ayrshire NST, the Minimal Eating Observation Form Version Two (MEONF-II), NNSA, Nutrition Risk Screening (NRS) and NUFFE (all contained recent weight loss, reduced intake/swallowing difficulties, reduced appetite and inability to self-feed) (Table 7).

3.4. Practicability

The highest scoring tools for practicability were the Simplified Nutritional Appetite Questionnaire (United States Tool) (SNAQ-US), the Short Nutritional Assessment Questionnaire (the Netherlands tool) (SNAQ-NL), MST and Canadian NST (13/15). The Canadian NST, MST, SNAQ-US and the Simple Nutritional Screening Tool (SNST) were found to be the least time consuming (8 out of maximum 9 points), while the MEONF-II and the Nagel NST were found to be the most time consuming (0/9). Fifteen tools were cost-free (questionnaire only), while the majority (n = 25) required a weighing scale, tape measure or stadiometer. Nine tools required costly equipment [laboratory use, Dual-energy X-ray absorptiometry (DEXA) and/or Bioelectrical Impedance Analysis (BIA)]. Many tools (n = 20) were available in more than one European language. For most tools (n = 39/48), it was reported that the tool could be used by multi-disciplinary staff (Table 7).

4. Discussion

The highest scoring malnutrition screening tools were the DETERMINE your health checklist for the community setting, the Nutritional Form for the Elderly (NUFFE) for the rehabilitation setting, the Short Nutritional Assessment Questionnaire-Residential Care (SNAQ^{RC}) for residential care and both the Malnutrition Screening Tool (MST) and the Mini Nutritional Assessment Short Form (MNA-SF-V1) for the hospital setting.

4.1. Development of the scoring system

Question format and weightings underwent many rounds of discussion with our expert panel before the final scoring system was agreed. Validation, parameters and practicability were considered equally important elements of malnutrition screening tools. Whether validation should have been given a higher weighting is open to discussion, as it could be argued that a tool must be valid before other aspects are to be considered. This is indeed true;

however, previous work critically evaluating the validation of malnutrition screening tools concluded that validation results and study design of previously published validation studies are too weak across all settings, and that recommendations on the best tools can presently not be based solely on validity [4]. This is confirmed in the present review, where validation scores for all tools were only about 50% of the maximum score of 15. As many tools are already available, further examining the validity of current screening tools, particularly those which scored high for parameters and practicability in this study, is preferable to the creation of new tools.

4.2. Application of the scoring system

Our scoring system identified five malnutrition screening tools which currently appear to be best to use with older adults across community and healthcare settings to screen for risk of malnutrition.

The DETERMINE Your Health Checklist [13] includes parameters such as decreased food intake, dental issues, mobility issues, and polypharmacy, all of which have been reported as determinants of malnutrition in older adults [14–17]. The checklist contains ten, easy to interpret questions which the older community-dwelling adult can self-administer, as no anthropometric measurements are required, further contributing to its practicability in this setting. The NUFFE tool [18] contains 15 questions, similar to those in DETERMINE, and can also be self-administered with no anthropometric measurements needed. As NUFFE was designed for the rehabilitation setting, it is not surprising that it received the highest score for this setting. The SNAQ^{RC} [19] was developed in the Netherlands for residential care. It is quick and easy to use, containing just four questions, including weight loss, ability to self-feed, appetite and BMI [10,20,21]. The MNA-SF-V1 [22] is the most frequently validated tool in the hospital setting, and contains parameters applicable to older adults, such as cognitive function and mobility issues. However, all validation studies of the MNA-SF-V1 in the hospital setting used the MNA-FF as the reference standard, introducing incorporation bias. This was addressed in the scoring system, as a negative mark was appointed to the MNA-SF for studies against itself (question 5). Nonetheless, it received the highest score of all tools for this setting. Further studies using clinical assessment by a nutritionally-trained professional or the SGA would enhance this recommendation. The MST [23] scored equally well for the hospital setting. This tool was the only highly scoring tool not originally designed for use with older adults, but scored highly for practicability and contains only two parameters, both of which have been considered appropriate determinants of malnutrition in an older population. Both the MNA-SF-V1 and the MST are quick and simple to use and require minimal training, which enhances their suitability for the hospital setting where time constraints are documented as the major barrier to malnutrition screening. It is worth noting that although the MNA-SF-V1 and the MST scored equally overall, the MNA-SF-V1 scored higher for parameters and the MST scored higher for practicability, which may influence which tool is chosen for use in a particular hospital setting.

Interestingly, the overall scores were highly similar for the best tools (Table 3). All scored low for validation, most scored highly for parameters and a mixture of results was found for practicability. It is worth noting that the overall scores were quite low (all reached approximately 60% of the highest achievable score of 45). This highlights the need for future research on these selected tools.

4.3. Validation considerations

A major finding from this study was that validation scored poorly for all tools across all settings under investigation. Tools which scored highest for validation were the MNA-SF-V1 and the MST in the hospital setting; however, both tools only received a score of eight out of a possible 15. There are two possible reasons for this. If the scoring system was designed to rate the validation results of tools alone (i.e. sensitivities and specificities), like previous systematic reviews have done [5,24], scores from the validation section of our scoring system would have been higher. Sensitivity and specificity values range from 6 to 100% and 12–100% respectively; therefore, rating tools based on sensitivity and specificity alone would have given high scores to certain tools (e.g. tools which reported sensitivity and specificity >80%, but had poor study design). Furthermore, by evaluating study design, level of evidence and type of validation, together with validation results using eight carefully selected questions, this added an extra critique of each tool's validity compared to the systematic reviews referenced above, and allowed for thorough critical appraisal of the validation of each tool. Therefore, a more truthful picture of the validity of each tool in each healthcare setting was achieved.

Some tools were validated against all methods (MNA-FF, SGA, and clinical assessment by a nutritionally-trained professional), and had evidence of predictive validity. However, no tool was validated against all methods in a particular setting/one setting. Therefore, a score of 15 points was not achievable at the time of the study. Appropriately conducted validation studies on the selected tools are needed.

4.4. Parameters and practicability considerations

As mentioned earlier, a body of evidence exists to suggest that parameters used with the general adult population (e.g. BMI of 18.5 kg/m^2) to screen for risk of malnutrition may not be an accurate measure of risk in older adults [25]. The Ayrshire NST [26], NNSA [27] and NUFFE [18] all contain more than one question considered highly suitable for measuring malnutrition risk in older adults (e.g. cognitive decline, BMI less than 20 kg/m^2 and unintentional weight loss) and, interestingly, these three tools were designed for the older adult population. Biochemical markers are highly inconvenient for screening for risk of malnutrition in all settings, and there is evidence to suggest these markers do not reflect malnutrition in older populations, but rather an under-lying disease state [11,28]. Tools such as CONUT and the GNRI scored poorly in this section as both contain biochemical measures [29,30].

On consideration of the practicability of each malnutrition screening tool, the time and cost of many tools were underreported. Furthermore, tools which reported use of less than 5–10 min, but require biochemical measurements, were considered 'high-time consuming'. In order to standardise the time and cost of each tool, we devised a method of assessing how much time and how costly each tool was. Tools which scored highest in this section were the Canadian NST, MST, SNAQ-NL and SNAQ-US [23,31–34]. All were considered low-time consuming and did not require costly equipment. They are easily downloadable from the internet and have been used in multiple settings.

4.5. Further considerations

Another critical aspect of appraising malnutrition screening tool is reliability analysis. Reliability has been widely discussed as an important measure of a tool's performance as it measures the agreement of results obtained between two administrators (inter-rater reliability) or between results from the same administrator at different time points (intra-rater reliability). However, although we have been advised to measure reliability of tools over a decade ago, [35] little evidence exists on the reliability of malnutrition screening tools in any setting. We conducted a

review of reliability studies after our initial study using the scoring system and found both poor study design and results for all tools. Some studies reported analysis of reliability when this was not the case, and others provided little information on study design. Furthermore, if a screening tool is not valid and fit for purpose (i.e. it does not detect the condition or risk of the condition under investigation), it is deemed of little practical relevance, even if it reports good reliability. It was, therefore, considered that inclusion of reliability would not add value to our scoring system at present. However, should reliability studies be conducted in a more standardised and thorough manner in the future, a reliability section would add value when scoring tools. Investigation into the reliability of malnutrition screening tools would benefit from a thorough critical review of the current reliability studies in the literature, similar to our previous review of the validity of malnutrition screening tools. [4]

4.6. Impact of the study findings for research and healthcare

As this study has not only taken the validity of tools, but also their parameters and practicability into account, it has created a new approach to how we critically review malnutrition screening tools. The results can be used by researchers and healthcare professionals to aid their decision-making on which malnutrition screening tools are most appropriate for use with older adults in their setting of interest. This study indicates the tools that scored highest in each setting. However, we suggest readers should decide which of the three rating domains are most important and appropriate for their purpose; for example, for a research project, validity may be considered most appropriate, whereas healthcare professionals looking to implement screening into daily practice may consider that practicability is of higher priority.

It could be argued that recommending different tools for different settings may over-complicate malnutrition screening and potentially cause confusion among healthcare workers. Although this is a valid concern, our research has highlighted that in older adults, different tools appear more valid and suitable in different settings, suggesting that using one tool across all settings will not permit accurate identification of risk of malnutrition in this vulnerable cohort. Furthermore, training healthcare professionals working with older adults on tools that are appropriate to their place of work is worthwhile if it facilitates early identification and better management of patients/clients in their care.

5. Conclusion

Based on the developed scoring system for malnutrition screening tools for older persons and the 48 tools identified in the literature, the DETERMINE Your Health Checklist, NUFFE, SNAQ^{RC}, MNA-SF and MST tools scored highest for malnutrition screening of older adults in community and healthcare settings in Europe. Validity was poor across all tools in all settings, highlighting the need for increasing quality and standardisation of future validation studies. Several tools contained parameters which are considered unsuitable for measuring malnutrition risk in older adults. Many tools were considered practical for use, but some were considered time-consuming and costly. Based on this scoring system, it is not advisable to create more tools, but to improve the evidence for those which already exist. Screening practices in older adults across Europe could be improved by selecting valid and practical malnutrition screening tools that include parameters appropriate for older adults.

Expert panel

The scoring system development expert panel: Prof Jürgen Bauer, Assoc Prof Clare Corish, Dr Susanne Leij-Halfwerk, Prof Marian de van der Schueren.

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Conflicts of Interest

None to declare.

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